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(54) AIRCRAFT WITH FANS FOR VERTICAL LIFT

(54)

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ABSTRACT:

CLAIMS: Show all claims

*** Note: Data on abstracts and claims is shown in the official language in which it was submitted.

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This invention relates to aircraft and particularly though not exclusively to aircraft designed for high speed flight. Such aircraft normally have a high wing loading and hence very long landing and take-off runs are necessary. To curtail and possibly to eliminate the landing and take-off runs, it is necessary to make provision for imparting a vertically upwardly directed thrust to the aircraft in addition to the aerodynamic lift afforded by the wings.

The upthrust required may be afforded by a downwardly directed jet stream from a gas turbine jet propulsion engine. This arrangement however has the disadvantage that the jet stream is at a very high temperature and is liable to cause damage for a considerable distance around the aircraft as it takes off or lands. Further, the jet stream velocity is high and so the ratio of lift to power is low.

Accordingly, the present invention provides an aircraft powered by a gas turbine jet propulsion engine, the exhaust gases from which are discharged rearwardly through a jet pipe as a propulsive jet stream for normal forward flight, and further having a fan mounted therein with its axis substantially vertical, the fan drawing in air from atmosphere and discharging an air stream downwardly so as to produce an upward component of thrust on the aircraft, means operable at will being provided for diverting the exhaust gases from the jet pipe to drive the fan.

It will be seen that the fan discharges a large mass flow of air at comparatively low velocity and substantially at ambient temperature, and accordingly the disadvantages referred to above are minimised.

Preferably the diverted exhaust gases are discharged through turbine rotor blades drivingly connected to the fan rotor. The fan may have the turbine rotor blades mounted on the periphery of the rotor thereof.

In one form of the invention, there are two fans for giving upthrust, symmetrically arranged with respect to the centre line of the aircraft, both being driven by the exhaust gases from the jet propulsion engine. In a large

aircraft powered by a plurality of jet propulsion engines there may be two fans associated with each engine. Alternatively, two or more engines may discharge exhaust gases into a common jet pipe from which exhaust gases may be diverted to drive two fans.

One embodiment of the invention will now be described with reference to the accompanying drawings, of which:-

Figure 1 is a diagrammatic plan view of a jet propelled aircraft having fans for giving vertical lift, part of the upper surface of the aircraft being shown as broken away to show the interior construction.

Figure 2 is a diagrammatic cross-section of the aircraft wing on the line II - II in Figure 1.

Figure 3 shows a detail of the aircraft jet pipe.

Figure 1 shows a small high speed aircraft comprising a fuselage 1 and wings 2 of delta configuration and powered by a gas turbine jet propulsion engine 3 of known type mounted centrally within the fuselage. The engine 3 draws in air through air intakes 4 in the wing roots and discharges the exhaust gases rearwardly as a propulsive jet stream through a jet pipe 5 extending along the centre line of the fuselage 1 and terminating in a jet nozzle 6 at its rearward extremity. The jet pipe is circular in internal cross-section immediately rearwardly of the engine and at the nozzle but comprises an intermediate portion 5a which is rectangular in cross-section, the circular and rectangular portions being joined by connecting portions which progressively change in shape without substantial change of cross-sectional area. The rectangular portion 5a is provided with two branch pipes 7, one on each side thereof, which intersect the jet pipe at an acute angle so that the entries to the branches face upstream relative to the jet stream. Means are provided for diverting the exhaust gas stream into these branch pipes as will be explained below.

The aircraft is further provided with two fans 11 symmetrically arranged on each side of the centre line of the aircraft, one being mounted in each wing

with its rotor axis substantially vertical and arranged to draw in air from atmosphere and to discharge it downwardly so as to impart an upthrust to the aircraft. The fan rotors 12 rotate in opposite directions, thus balancing out gyroscopic effects. Each fan rotor 12 comprises a hub 12a, a row of fan rotor blades 12b extending outwardly therefrom and a shroud ring 12c connecting the tips of the fan rotor blades (see Figure2). Each rotor 12 further has a row of axial flow turbine rotor blades 12d mounted on the outer surface of the shroud ring 12c. Exhaust gases diverted from the jet pipe 5 are supplied to these turbine rotor blades 12d through a turbine inlet volute 13 mounted immediately above the fan rotor 12. Each volute 13 has a downwardly facing annular outlet provided with turbine nozzle vanes 14 co-operating with the turbine rotor blades 12d.

The arrangement for diverting the exhaust gases from the jet pipe comprises two pairs of butterfly valve discs 15, 16 (see Figure 3). The pivotal axes of the discs lie transverse to the jet pipe and the branches and are chosen so as to minimise the moments which must be exerted to turn the discs and to control their position. For forward flight the discs 16 close the entries to the branch pipes 7 while the discs 15 lie edge on to the exhaust gas stream which is discharged rearwardly through the jet nozzle 6 as a propulsive jet stream. For take-off and landing, and in hovering flight, the discs are turned about their pivotal axes by suitable actuating means (not shown) such as hydraulic jacks so that the upstream edges of discs 15 meet in midstream to block the jet pipe while the discs 16 open the branches 7 as shown in Figure 3. The exhaust gases are thereby diverted into the branch pipes 7 and flow through the turbine inlet volutes 13 to drive the turbine rotor blades 12d which thereby drive the fans. As shown, the discs 16 are somewhat curved to guide the gases into the branch pipes 7.

In transition from vertical to horizontal flight and vice versa, both forward and upward thrust may be required, and so an intermediate position of

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the discs may be selected.

The rectangular portion 5a of the jet pipe may conveniently be split longitudinally by a central partition with which the upstream edges of the discs 15 engage when the exhaust gases are being diverted. Various other arrangements for diverting the exhaust gases may be used, for example, the linked butterfly valves described in copending Canadian Patent 530,777. Other possible arrangements are described in Canadian Patent 567,250.

As shown in Figure 2, the inlets of the two fans 11 communicate direct with atmosphere through inlets 17 in the upper surface of the wing. In an alternative form of the invention they may be connected to one or more boundary layer suction openings in the surface of the aircraft so that the lift may be further augmented or controlled at low forward speeds. These suction openings may be constituted by suction slots or by portions of the surface of the aircraft made of porous material in known manner.

The fans 11 discharge air streams vertically downwards through openings 18 in the undersurface of the wings. The exhaust gases from the turbine blades are also discharged downwardly and so serve to augment the upthrust on the aircraft. The quantity of exhaust gases is small compared with the quantity of air so that the high temperature of the former should not give rise to any difficulty.

The downwardly discharged exhaust gases may be directed with a radially inward component of motion, so that they will mix with the cool air discharged by the fans before reaching the ground.

Rows of stator blades 19, 20 are provided immediately upstream and downstream of the fan rotor blades 12a. These blades 19, 20 may be adjustable to enable the vertical lift to be varied, and the pitch of the fan rotor blades 12b may be variable for the same purpose. Control of the aircraft may be effected by differential control of the blading of the two fans. Alternatively or in addition the turbine nozzle vanes 14 may be adjustable.

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Means are provided for closing the air inlet and outlet openings 17, 18 in the surfaces of the wings when the fans are not in use. The openings 17, 18 are provided with cascades of pivoted vanes 21, 22 which are pivoted between a position in which they lie edge on to the air flow through the openings to one in which they lie flush with the surface of the wing to close the openings. In Figure 2, the vanes are shown in the "open" position. Again the vanes 21, 22 of the two fans may be operated differentially for control of the aircraft.

In order to control the movements of the aircraft at low speed and in hovering flight, additional fans are provided, arranged to discharge streams of air in directions such as to exert turning moments or side forces on the aircraft in a sense to exercise the desired control. Thus there are fans 23 mounted in the aircraft wing tips with their axes vertical so as to exert moments about a longitudinal axis, and a further fan 24 is mounted with its axis vertical in the extreme nose of the aircraft so as to exert a moment about a transverse axes. In addition there may be a fan mounted in the fin of the aircraft with its axis extending horizontally and transversely of the centre line of the aircraft so as to exert a moment in the yawing plane. These fans 23, 24 are smaller than the fans 11 for giving upthrust but are provided with turbine rotor blades for driving them in a like manner. The turbine blades for these fans are driven by compressed air bled off from the compressor of the main gas turbine jet propulsion engine 3 and led to the fans through pipes 25, 26. The control of these fans may be achieved in a like manner to that of the upthrust fans 11. The fan apertures are provided with cascades of vanes 27 for closing them when not in use.

The invention may also be applied to a large multi-engined aircraft. In this case there may be a plurality of gas turbine jet propulsion engines distributed along the wing span, each being associated with two or more fans in the manner already described. Alternatively the engines may be arranged in one or more groups, the engines of each group discharging

into a common jet pipe having branch pipes leading to two or more fans. Thus failure of one engine of a group may be compensated for by increasing the output of the remaining engines.

In an aircraft of the type described it may be important for the pilot to know the thrust which is exerted by each fan. Accordingly a device may be provided in association with each fan which registers the thrust. The device might take the form of a pressure-sensitive element in the air stream through the fan, or a strain gauge or pressure capsule registering the load on the fan rotor bearings.

...x embodiments of the invention in which an exclusive property or ...ege is claimed are defined as follows:

1. An aircraft comprising a gas turbine jet propulsion engine having a jet pipe for the rearward discharge of a propulsive jet stream, a ducted fan mounted internally of the aircraft and arranged to draw in air from atmosphere and to discharge an air stream downwardly so as to impart an upwardly directed thrust force to the aircraft, turbine rotor blades in driving connection with the rotor blades of the ducted fan, a branch pipe from the jet pipe leading to the turbine blades, and a jet deflector at the junction of the branch pipe with the jet pipe and operable to deflect the jet stream into the branch pipe to drive the turbine blades.

2. An aircraft according to claim 1 wherein the turbine rotor blades are mounted on the tips of the fan rotor blades.

3. An aircraft according to claim 1 or claim 2 wherein the ducted fan comprises a row of angularly adjustable fan rotor blades.

4. An aircraft according to claim 1 or claim 2 wherein the ducted fan comprises a row of angularly adjustable fan stator blades.

5. An aircraft according to claim 1 or claim 2 comprising turbine inlet nozzle vanes associated with the turbine rotor blades, said nozzle vanes being angularly adjustable.

6. An aircraft according to claim 1 or claim 2 wherein the ducted fan is arranged to discharge its air stream through an aperture in the undersurface of the aircraft, said aperture being provided with vanes pivotable between a position in which they close the aperture and a position in which they lie edge on to the air streams discharged therethrough.

7. An aircraft according to claim 1 comprising at least one further ducted fan mounted internally of the aircraft and arranged to draw in air from atmosphere and to discharge an air stream in such a direction as to exert a turning moment on the aircraft.

8. An aircraft according to claim 7 wherein said further fan is mounted with its axis vertical at the aircraft wing tip.

9. An aircraft according to claim 7 wherein said further fan is mounted with its axis vertical at the nose of the aircraft.

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10. An aircraft according to claim 7, claim 8 or claim 9 comprising turbine rotor blades in driving connection with the rotor blades of said further fan, and means for leading compressed air from the compressor of the engine to drive the turbine blades.

11. An aircraft comprising a gas turbine jet propulsion engine having a jet pipe for the rearward discharge of a propulsive jet stream, a pair of ducted fans mounted internally of the aircraft, one on each side of the jet pipe, the fans being arranged to draw in air from atmosphere and to discharge air streams downwardly so as to impart an upwardly directed thrust force to the aircraft, turbine rotor blades in driving connection with rotor blades of the ducted fans, branch pipes from the jet pipe leading to the turbine blades, and jet deflectors at the junction of the branch pipes with the jet pipe and operable to deflect the jet stream into the branch pipes to drive the turbine blades.

12. An aircraft according to claim 11 wherein the engine is mounted within the aircraft fuselage with the jet pipe extending along the aircraft fore-and-aft centre line, and the ducted fans are mounted with their axes substantially vertical within the wings and symetrically disposed one on each side of the centre line.

13. An aircraft according to claim 11 or claim 12 wherein the turbine rotor blades are mounted on the tips of the fan rotor blades.

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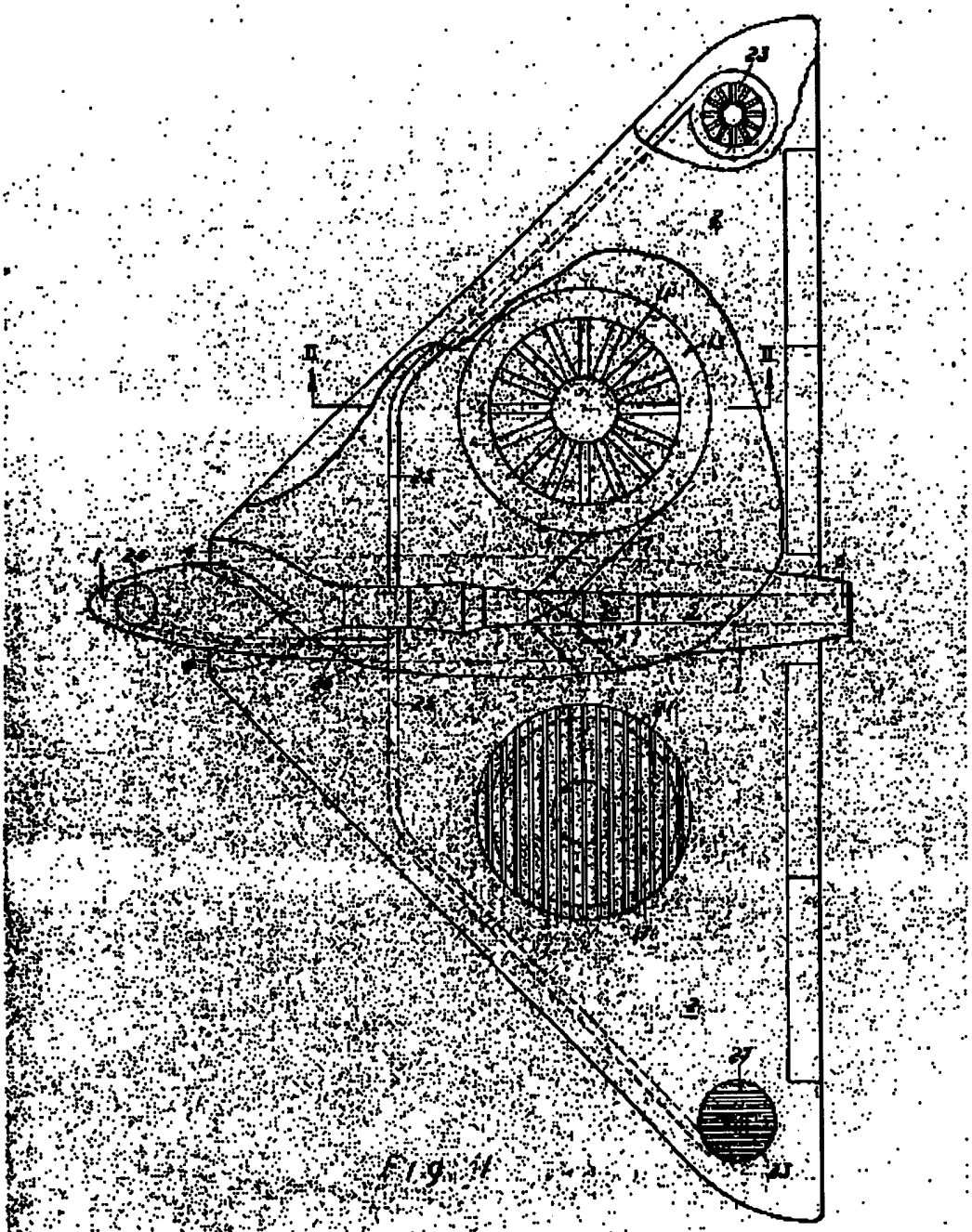

Fig. 1

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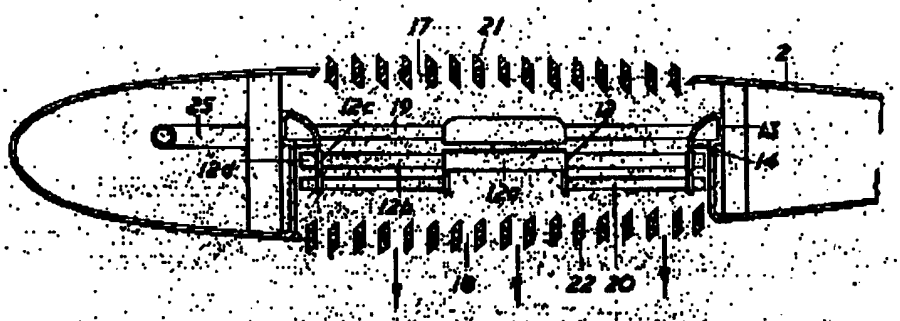

Fig. 2

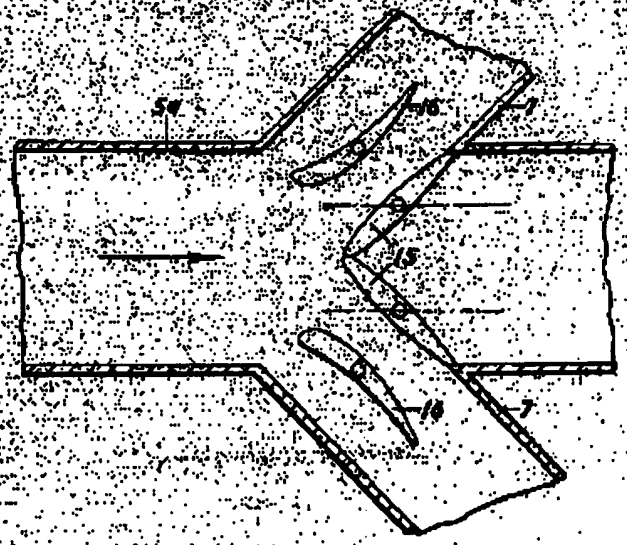

Fig. 3

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